SEASONAL VARIATIONS IN THE PLANKTON of
FLORENCE LAKE

by
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Charts of Hauls from the Six Stations
I wish to extend to Dr. C. McLean Fraser my appreciation of his encouragement, advice, and whole-hearted support throughout this project. May it prove worthy of his confidence.

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INTRODUCTION

Any work on fish culture or fish preservation involves at some stage of its progress the food of fishes. This, reduced to the ultimate end, centres around planktonic forms.

The realization of this fact has, within recent years, caused a considerable study of this phase of life. This is especially true in the case of the study of fresh-water organisms. Very little work on fresh-water biology has been done in British Columbia, except around a few lakes where fish hatcheries are located. It is fitting that a broader knowledge of the plankton forms of the fresh-water lakes in British Columbia should be had, both from an economical as well as zoological point of view.

It was with a view to studying fresh-water planktonic forms and observing their seasonal variation that Dr. C. McLean Fraser suggested that a survey of Florence Lake, Vancouver Island, be made as a fit and timely piece of research work.
Florence Lake - looking North

The East N.-East Shore.
East Shore - Station 1

East Shore - Central Region
South Shore.  Station - 2

South-west Shore. Station-2 extends from area shown in the top photo to the spot x in the lower.
West Shore. Station - 3.

North End of the Lake. Station - 4.
3.

FLORENCE LAKE

Location and Size.

Florence Lake is located ten miles W. N. W. of Victoria, B. C., at Latitude 48°27'36"", Longitude 123°30'45" with an elevation of approximately 200 feet above sea level and about a quarter of a mile north of the Island Highway.

It occupies a small oval basin a quarter of a mile long and an eighth of a mile wide; bordered on the west and north by a hill of altitude 500'-600'; on the east by a rise of about 100'.

Marshy areas mark the north and south boundaries. The northern area, which is limited by the contour of the hill on that shore, dries up as the summer approaches. The southern area, which may extend as far as the Island Highway at flood water, in summer consists of a small pool connected with the south-east corner of the lake by a low depression; while the northern consists of a boggy area which dries up as the season advances.

During the winter a small stream, from a swamp two miles away, drains into the north-west corner of the lake. Due to the absence of an outlet the resulting rise in the lake level causes an overflow into the marshy areas described above.

It is quite probable that at one time Florence lake connected with Langford lake about one mile away.
Contours and Depths.

The shore line is fairly regular. At the southern extremity two shallow bays are present, while at the northern a bend in the lake forms a third.

The greatest depth sounded was 20' (summer readings). The average depth was 12'-15'. The accompanying map will give an idea of the relative depths and general shallowness of the lake.

The western shore shelves most quickly, due to its bordering along the foot of the hill.

Extensive shallow areas of from 2'-4' extend out from the southern and northern shores to a distance of 50'-60'. At the southern end the depth is 12' about 100' from the shore; at the northern end it is approximately 6'. The shallow area here is probably greater than at the southern end for reasons to be suggested later.

In general the 4'-6' depth along the eastern side extends 30'-40' from the shore and is marked by the area of Nuphar polysepalum, which becomes wider at the northern and southern ends.

Ecological Zonation.

Florence lake may be considered as belonging to the third class of temperate lakes, viz., "Temperature of bottom water very similar to that of the surface water, circulation continuous except when frozen." (Welch. 1935)

It may be divided into the following zones.

1. The shore margin.

(a) Consisting of an encroaching area of Ledum
greenlandium. This extends from the north-west border, thinning out along the east-south-east border where a bank of rock slopes into the lake; widening again towards the east and south and becoming extensive along the south and south-west border. None exists along the west shore.

(b) A Typha area along the south-west margin, mingled to some extent with the Ledum.

(c) A rocky area along the central western shore with no marked characteristic growth.

2. The off-shore area.

(a) A mucky, rank-smelling ooze forming the lake-bottom in the Nuphar polysepalum area.

(b) A small area of Myriophyllum growing in black mud along the central region of the eastern shore.

3. Potamogeton Area (Three species?)

This is found at the south-west and north-east corners of the lake and extends out beyond the Nuphar area to a depth of 12'.

4. A central area where the bottom of the lake is composed of ooze, mainly consisting of decaying plankton material and fairly rich in diatomaceous deposits.

In general the lake has the appearance of gradually drying up. The area of Ledum is gradually extending outwards, while the Nuphar areas, particularly along the eastern shore, are becoming smaller. This may be due in part to the exposure of the roots of many of them during the low water level experienced during the last few years.
It may also be partly due to the destruction caused by muskrats, which have been increasing in numbers and have been seen feeding on this plant. Along the central portion of this shore the *Myriophyllum* has likewise been subjected to similar exposure during the low water. Whether it will continue to grow under these conditions is questionable. It appears to be a favourite haunt of the black bass fry.

The *Potamogeton* areas were found beyond the realm of the *Ledum* and, in general, beyond the mucky ooze of the *Nuphar* area. Muskrats were seen towing strands of this plant across the lake to their dens at the south-west corner.

*Brasenia*, an indicator of soft water, (Ricker, 1934), occurred in two localities, forming a fringe outside the *Nuphar* areas, namely along the south and north-east borders.

Some of the *Nuphar* was found to be growing at the edge of the 12' area.

**Seasonal Changes.***

Throughout the year the lake may have a rise and fall of 5'-7'. During 1933-34 the fall in level was over 5'; in 1934-35 a drop of over 6' occurred. This was the lowest level attained over a period of years.

Some idea of the rise and fall for the year may be obtained from the photographs of stations 1 and 2 which were taken in October, after the first rain when the lake
was almost at its lowest level. At station 1 the landing was 6" under water during the high water of the winter. At station 2 the lake level was within a foot of the landing.

In passing it may be noted that due to the presence of hills surrounding three sides of the lake the most prevalent wind is from the south-west. This is especially true during the summer when a strong breeze lasting an hour or two comes up in the morning about nine and again about four in the afternoon. This may, in part, account for the building up of the extended shallow area along the south-east.
RESULTS

The writer is well aware that many planktonic forms may remain at a depth beneath the surface of the lake and not be taken at the surface when hauls were made. These, if present, were neglected and comparative results were obtained of only those organisms which were taken at the surface, or showed a movement toward the surface of the lake at some time during the day.

Analysis of Plankton.

Arthropoda.

Insecta:

Chironomid larvae. Never very plentiful.
Chaoborus larvae. Seen during August and May.
Ephemera. One seen from Station 2 in August.

Ostracoda.

No attempt was made to identify these.

Copepoda.

Diaptomus washingtonensis Marsh
Cyclops bicuspídatus Claus (Typical)
Cyclops phaleratus Koch Very few found.
Nauplii

Cladocera.

Alonella nana (Baird)
Bosmina longirostris (O. F. Müller)
" longispina Leydig
Ceriodaphnia lacustris Birge (?)
Ceriodaphnia reticulata (Jurine)
Daphnia longispina var. hyalina Leydig forma typica.
Diaphanosoma brachyurum (Liéven)
Holopedium gibberum Zaddach
Pleuroxus denticulatus Birge

Malacostraca:
Hyalella azteca Saussure (vid. L. G. Saunders 1933)

Hydractiina:
No attempt was made to classify members of this group.

Rotifera:
Asplanchna priodonta Gosse. Fairly frequent.
Chromogaster (Anapus) ovalis (Bergendal). Confused with Gastropus stylifer. More common than the latter in winter.
Colurella (Colurus) bicuspidata (Ehrenberg) Rare.
Conocephalus unicorns Rousselet. Common.
Diurella procellus (Gosse). Rare.
" stylata Eyferth. Rare.
Euchlanis dilatata Ehrenberg. Rare.
Gastropus stylifer. Imhof. Common; disappears during the winter.
" " quadrata (Müller). Fairly common in winter.
Lepadella patella (Müller). Rare.
Monostyla lunaris (Ehrenberg)
10.

Monostyla bulla Gosse. Rare.

Notholea longispina (Kellicott). Never found in abundance. A summer form.

Notholea striata acuminata (Müller). Never abundant, a summer form.

Ploesoma truncatum (Levander)

Polyarthra trigla (platyptera) Ehrenberg

Trichocera cylindricus (Imhof)

Synchaeta sp.

Gastrotricha:

Although commonly found among water plants and ooze two specimens belonging to the genus Chaetonatus were taken in the plankton hauls for May.

Tardigrade:

Like the above group these organisms are to be found crawling among the debris and plant ooze of shallow water. Two specimens were taken in the hauls for June.

Protozoa:

Arcella vulgaris Ehrenberg. Present most of the year.

Arcella discoides Ehrenberg

Geratium hirundinella (O.F.M.) Schrank.

Dinobryon sociale Ehrenberg (sp.?)

Epistylis sp. Ehrenberg

Mallomonas sp. Perty

Peridinium sp. Ehrenberg
11.

**Vorticella campanula** Ehrenberg

**Polyzoa:**

Statoblasts of *Plumatella* (polymorpha?) were plentiful during December. Some were obtained up till April.

**Desmidaceae:**

*Arthrodemesus* Ehrenberg. Probably *A. incus*. Rare. Seen in May.

*Closterium* Nitzsch. Rare. Seen in early spring hauls.

*Cosmarium circulare* Reinsch (sp. ?). June, July, and August. More common in July.

*Cosmocladium* Rare. One or two specimens seen.

*Docodium* de Brébisson. Rare. Late spring and summer hauls.

*Euastrum* Ehrenberg. Rare. Seen in March.


*Microasteriast* Agardh. Two seen in June.

*Sphaerocyctosma* Corda. Common form throughout most of the year. Most abundant in early spring.

*Staurastrum* Meyen:

- *S. limneticum* var. *cornutum* G. M. Smith (1)
- *S. setigerum* var. *brevispinum* (?) G. M. Smith. fairly common.
- *S. cremulatum* Nageli. Fairly common in June.

*Xanthidium* Ehrenberg:
X. antilopaeum Kütz. May and Sept.
X. subhastiferum W. West.
Both common though never plentiful.

**Bacillariaceae:**

*Asterionella formosa* Hass. Tremendous bloom in December. Seen throughout the year.

*Anomoeoneis* Pfitzer (?). Small forms fairly abundant.

*Cymbella* Agardh. Very few seen.

*Campylodiscus* Ehrenberg. Seen in July 1934, and during the late spring of 1935.

*Ceratoneis arcus* (Ehr.) Kütz. Peak appeared to be in August; seen throughout the year.

*Fragilaria* Lyngbye. Has a peak with *Asterionella* though never as abundant.

*Meridion* Agardh. Probably *M. circulare* (Grev) Ag. Common throughout most of the year, though never abundant.

*Navicula* Bory

*Pinnularia* Ehrenberg. Fairly common, though never abundant.

*Stauroneis* Ehrenberg. Commonest in December.

*Tabellaria fenestra* (Lyngb) Kütz. Most common in the spring, though never abundant.

*Rhizosolenia criensis* H. L. Smith (?). Recorded in July 1934.
Myxophyceae (Blue-green Algae):

Anabaena lemmermanni (?) P. Richter. Most abundant during June.

Aphanocapsa Nägeli. Most abundant in the spring and early summer hauls.

Chamaesiphon A. Braun and Grunow. These were found on algal filaments. Never plentiful.

Chroococcus Nägeli. Fairly common in spring.

Coelosphaerium Nägeli

Eucapsis Clements and Shantz. Fairly common in the summer, though never abundant.

Gloeocapsa Kützing. Abundant in early spring to summer. Present most of the year.

Gloeotrichia echinulata (J.E. Smith) P. Richter (?)

Lyngbya Agardh. Never very common.

Merismopedia Meyen. Not common. First observed in March. More abundant in May.

Microcystis (Clathrocystis) Kützing. Never as plentiful as Aphanocapsa. Rise in numbers from May to July.

Heterokontae:

Characiopsis cylindricum Lemm. (?) Found on copepods. More abundant in the summer.

Chrysophyceae:

Mallomonas Perty

Synura Ehrenberg. Not very common.

Chlorophyceae:

Ankistrodesmus Corda. Fairly common in early
Dactylococcus Nägeli (?). A specimen resembling this algae was found in May.


Dimorphococcus lunatus A. Br. One seen in May.


Eudorina elegans Ehrenberg. Most common in late spring and fall.


Elakatothrix Wills. Fairly abundant in March.


Gloeocystis Nägeli.


Golenkinia Chodat. Never very abundant.


Gloeocystis Nagell.


Golenkinia Chodat. Never very abundant.


Gloeocystis Nagell.


Pediastrum Boryanum (Turp) Menegh. Never very plentiful.


Quadringula Printz. Incidental in appearance in the spring.


Selenastrum Reinsch. Rare. (?)


Sphaerocystis Chodat. Reaches a peak in early summer.


Spirogyra Link. Never very abundant. More in the spring and fall.


Volvox L. 1 specimen seen in March.


Zygnema Agardh. More seen in the winter hauls.


This list of organisms does not pretend to be a complete list of those present in the lake plankton. They indicate some idea of the variety present and the dominant forms.

Insufficient knowledge of algal classification prevented a complete analysis of all forms present in the hauls. The
one listed are those which were traced down with a fair degree of accuracy and certainty.

An analysis of the fauna of the lake bottom, the stems of the aquatic plants, etc., would probably add considerably to the present list to include tardigrades, tube-forming rotifers, insect larvae, turbellarians, and leeches. Such an analysis is beyond the scope of the present work.

The included tables show the counts for the various organisms over a period of one year. A study of them will give some idea of the seasonal variations that occur in the different groups. Graphs show the fluctuations of the more outstanding and important groups.
METHODS EMPLOYED

As pointed out by various workers on plankton organisms, no single haul from any part of a lake will give a representative sample of the organisms present.

Such ecological variation as is presented by the rocky shore on the west side of Florence lake and the oozy character of the remainder of the lake shore, suggested the possibility of some variation in planktonic forms. In order to test the possibility of such a variation hauls were made from six stations on the lake. This was for a twofold purpose; viz.

a. To determine if there might be some variation in the quantity of plankton from different parts of the lake.

b. To determine if there might be some variation in the forms of plankton from different parts of the lake.

Objections will be raised to the first on the grounds that the effectiveness of the net is not always the same and therefore some variation in efficiency might occur during the taking of the samples. To this it might be said that no dogmatic conclusions can be drawn from the figures in the results but they merely suggest some idea of the relative quantity of the various organisms from the different stations. No net apparently, is more than 40% efficient. This will vary with the quantity of plankton present and the distance through which it is hauled.

Further, the volume of the water passing through the net was not determined but a definite distance for each station was chosen through which the net was drawn. Here, again, a
better idea of relative quantity of the organisms might have been obtained if the length of the hauls had been made the same for all the stations. Comparisons showing relationships can possibly be made by bringing the results obtained to a common factor; namely, making each station a distance of 500 feet. There are objections to this that by increasing the hauls in this manner, the source of error is also increased.

Light as a distributing factor was taken into consideration by taking hauls from the same stations at different times of the day to determine the possibility of a suggested correlation between the number of organisms present and the amount of light. No attempt was made to measure the amount of light at any time or the depth of penetration into the water of the lake. A statement is made of the presence or absence of sunlight, shadows, or moonlight.

Surface hauls were made once a month over a period of one year (1934-35) from six stations on the lake. Due to unavoidable circumstances no hauls were made in September 1934. During January 1935, the freezing over of the lake prevented the taking of any hauls.

In making the surface hauls a six inch diameter net of #25 bolting silk to which was attached a 20 c.c. vial, was towed from the back of a slowly moving rowboat. The sample thus obtained, was allowed to settle and then reduced to a 10 c.c. volume. A few drops of formalin was used as a preservative.

It is quite probable that a larger net might have been
used to advantage. Realization of such a probability did not occur until the work was too far advanced to change the procedure.

A vertical haul was made to see if any organisms not obtained from the surface were present between the surface and the bottom of the lake. Here, in particular, a larger net would have been of advantage.

Stations and Hauls Made from Each.

Surface hauls were taken once a month at noon and evening from Stations 1, 2, 3, 4, and 5. In addition to these a midnight haul was made once a month from Stations 2, 3, and 5. A vertical haul was made once a month from the centre of the lake (Station 6).

Length of Hauls.

Station 1. 250' along the east shore at the southern end outside a reedy area.

" 2. 400' at the southern end along the outside border of a lily bed and above *Potomogonet.*

" 3. 450' along the rocky west side of the lake.

" 4. 300' at the southern end of the lake above a bed of Potomogonet, outside a reedy area which merged into an area of water lillies.

" 5. A 500' tow from the centre of the lake.

" 6. A vertical haul from the centre of the lake.

Methods Employed in Making Counts.

An examination of the 10c.c. haul was made in a 10 cm. diameter petri dish under a binocular microscope (32mm. obj.
x6 eyepiece) to determine the presence of the crustacean forms and the larger rotifers. For making the counts a 1 c.c. cell marked off into 1/15's of a c.c. was used. This was similar to the cell used by Birge and Juday. Counts were made under the 16mm. objective of a monocular fitted with a mechanical stage. A total count of all the crustaceans, Asplanchna, Synchaeta, incidental rotifers; e.g., Colurella, and the larger algal groups; e.g., Anabaena. One-fifth of a c.c. was used as a unit volume to be counted for all other forms. The total counts were recorded as the number present in 1 c.c. of the original 10 c.c. volume of plankton obtained from the tows over a distance of 500'. Wherever the haul made was less than 500' the count of the organisms in that haul were multiplied by the factor of 500 that would make the length of the tow for that station equal to 500.

Whenever the quantity of plankton made a 1 c.c. count of the 10 c.c. volume impossible, the total volume was made up to 20 c.c. and results recorded as numbers present in a 1 c.c. sample of the original 10 c.c. volume. i.e., multiply the Cladocerans by 2, the algae by 10.

During December a bloom of Asterionella necessitated a 40 c.c. dilution of the original 10 c.c.'s for the making of the algal counts. The Crustaceans were counted from a 20 c.c. dilution. This was done to give more accuracy to the count of the small algae which would otherwise have been masked by the large quantity of Asterionella.

Objection will probably be raised to the use of these dif-
different dilutions on the basis that they do not give sufficiently correlated comparisons. A relative comparison can still be made. As stated previously, the figures for the numbers of each group present are intended to show relative frequency not exact number of organisms present. Such a result is impossible when dealing with a nomadic population. A general cross-section of the lake population is all that can be hoped for.

It is obvious that this method of counting might give too great a frequency in some cases to the "incidental organisms"; e.g., Euchlanis, but at the same time too small a proportion would be given to the small algal forms masked by the bloom of Asterionella and Peridinium.

Such difficulties as these are always present and seem unavoidable.

The rotifer counts presented some difficulties due to unfamiliarity with the group and the impossibility of using the high power (1.6mm.) objective of the monocular microscope with the counting cell employed. For this reason a very small rotifer was observed which could not be identified. A count and recording of it was made as an unidentified rotifer. Forms such as Asplanchna and Synchaeta were distorted in many cases by the preservative so that accurate determination of these could not be made, when such forms were met with. The trochal disc and foot in many of the Synchaeta were withdrawn giving the larger ones the appearance of Asplanchna. It is very probable that the majority of such forms seen during February were Synchaeta as this rotifer
has a sudden bloom during this period (Lotka 1925)

Chromogaster ovalis was at first confused with Gastropus stylifer. It is therefore included in with the counts of the latter and reference made as to which is the predominant form.

By the above grouping of the rotifers it is possible to give the relative variation in the total rotifer population and an idea of the variation (with the restrictions noted above) in the population in each group throughout the year.

Groupings of the Algal Forms.

The groupings employed were to facilitate counting and included forms of general similarity of make-up. The same forms were included in each group throughout the year; any "incidents" which might have warranted inclusion in one of the groupings employed was recorded separately. A record was made of the "dominant" form in any group and the relative proportion of the others. In the colonial forms the average number per colony was also recorded.

The following headings with their inclusive forms was employed.

Gloecocapsa - (Blue-green Algae)

Chroococcus Nâgeli. Dominant during March; continued till the Fall.

Gloeocapsa Kützing. Dominant during the Summer.

Eucapsis Clements and Shantz. Present in Summer

Aphanocapsa -

Microcystis Kützing. (Clathrocystis Henfrey)
Most abundant in June.

Aphanocapsa Nägeli. Most abundant in June.


Coelosphaerium Nägeli. Confused with regularly formed colonies of Aphanocapsa.

Micractinium-Fresenius (Richteriella Lemmermann)

Selenastrum

Selenastrum Reinsch, Rare. (?)

Ankistrodesmus Corda. Few of this form were seen.

Quadrigula Printz. Probably the most common form.

Elakatothrix gelatinosa Wille. Sporadic in appearance.

Sphaerocystis Chodat (Eutetramorus Walton)

Sphaerocystis Chodat

Gloeocystis Nägeli

Several small green algae were included, but the quantity of Sphaerocystis was always noted.

Most difficulty occurred in the placing of the unicellular green algae. Some of these may have been included among the Gloeocapsa group in spite of care to try to keep them in the Sphaerocystis group.

Diatoms and Desmids.

No attempt was made to make separate counts on the numbers of the different genera present. The dominant form in each month was recorded. In the case of Asterionella an attempt was made to give some idea of the number present.


**Protozoa.**

*Vorticella.* This was counted in relation to the numbers present on the colonies of *Anabaena*, where it was most frequently found.
DISCUSSION OF THE RESULTS.

Bottle X 15 for March from Station 1 and bottle X 31 for May from Station 5 (centre of the lake) were inadvertently broken. No counts of these could made.

No readings for temperature, pH, acid carbonate or light penetration were taken. Certain features regarding the results can be indicated only. Therefore, any suggestion as to "why they are so" is suppositional, needing further work to reveal correlation between the above mentioned factors and the plankton population.

As stated previously the purpose of this work was first to show the seasonal variations occurring in the plankton; secondly to show, if possible, any diurnal movement of the organisms that takes place; thirdly to show variation in quantity for the various parts of the lake. In these matters the results speak for themselves. In taking these results it should be borne in mind "no two taken with the same organisms present will show the same reactions of those organisms to their environment." (Welch, 1934)

It is therefore the object now to analyse the results as far as is possible from the data to hand and compare wherever possible with data from other lakes.

Crustaceans.

The total crustacean population reaches a peak in spring and autumn (Pearse, 1926). From the results one would say autumn and early spring with a higher peak in the latter.
Ceriodaphnia reticulata. (Jurine)

This species shows a decided peak in its occurrence from August to October with an indication of its presence in late July and early November. No hauls were taken during September but it is permissible to surmise from the results that the peak of its numbers would be in September. The forms taken during August were mainly of young individuals. Foerster (1925) reports this form to be found as early as June, but no individuals were taken from Florence lake so early in the season.

A variation in its numbers during the day is shown. An examination of the hauls from all stations shows a decided increase toward midnight after 5:00 p.m. During August the greatest numbers were found at Station 2. The numbers showed a decrease at the 6:00 p.m. haul and an increase at midnight. The haul from the centre of the lake showed an increase between the noon and the 6:00 p.m. haul. The same occurred at Station 4 at the north end of the lake.

Since the greatest numbers during August were found in the vicinity of Station 2 it is probable that this shallow weedy region was a breeding area or offered a rich food supply. Their distribution throughout the lake may be explained by the following:

About four o'clock in the afternoon a strong breeze rises and blows across the lake from the south-west to the north-east corner of the lake. This would probably cause a scattering of the organisms from the south-west corner to-
wards the north-east with the density of the population thinning towards the latter part of the lake. (Welch 1935)

"In general, horizontal distribution of plankton and alterations in it are largely of a mechanical character and less concerned with profound environmental differences such as are involved in the vertical distribution."

The hauls made in October were during a calm day. The general trend of the graphs is a steady rise till midnight. This would suggest a nocturnal movement with a possible indication that the adults prefer the deeper waters of the lake, at least during this month. Such a concentration in the centre would then be explained by Welch (1935), "Plankton which migrate vertically descend with the onset of dawn, those nearer the shore arriving at the bottom at a higher level, and, following the slope of the basin in order to reach deeper water, tend to concentrate in the depths; on the next trip to the surface they rise vertically from the profundal area, thus producing at the surface a greater concentration above the deep parts than above the peripheral regions." (Graph. I)

*Daphnia longispina var. hyalina* Leydig. Of this species in Cultus Lake Ricker (1934) says, "It is a warm-water species abundant from May to October. The preponderance of the form found in Florence Lake is toward the winter months; that is, from Nov. to April. This might be explained by an accumulation of Daphnia in the lower stratas of the lake during the summer months and rising to the upper strata during the winter
Seasonal Variation in *Daphnia longispina*  

Showing numbers at noon, 5:00 P.M., and midnight, for one day.
months. In the majority of the hauls a general tendency to rise to the surface at night is indicated during the summer. During October, November and December there is some indication in the colder regions of the lake of a rise during the afternoon and a settling beneath the surface during the night. The haul along the rocky shore during October and that from the shallow reedy portion at Station 2 appear to be exceptions. Aside from currents that might explain some of the exceptions that of Van Cleave (1924) might be added (in regard to Cladocerans) "Most react positively to weak light and negatively to strong. This may be reversed by other stimuli acting as controlling factors. In cold water they may act positively to light stimulus which would repel in higher temperatures." Could it be possible that the cold water during the winter months caused a negative tropism to light? Certainly in December the lake was frozen and during the winter months the rocky shore receives very little direct sunlight.

Welch (1935) quotes from other sources, "In a typical temperate deep lake it commonly behaves as follows: both young and full-grown individuals spend the after part of the night near the surface but descend during the day into the depths remote from the surface. ---in Lough Derg, Ireland, the young of D. longispina have the usual migration,—strangely enough the adults perform a reverse type of migration. It appears that the various forms of D. longispina, of which there are many, may differ in migration behaviour; for
example, it was found that in a certain Wisconsin lake—the form having rounded crests or helmets did not show diurnal movement, while that form with pointed crests showed such movement; in another lake containing both forms, the migration behaviour was exactly the reverse; in still another lake containing both forms, both manifested diurnal movement."

With regard to the different forms of *D. longispina* it is interesting to note that during July 1934, the form found was *D. longispina* var. *hyalina*. As the season advanced a change was observed in the general form—a sharper curvature of the head. This decreased toward the next summer. Again, during June of 1935, the decided *mendotae* and *galeata* forms were found. Many, during June and July, particularly from centre hauls had a coronet of three or four spines on the head. This form was seen by the author in one pool in the Tranquille lake region during July 1935. At least one individual in the July haul from Florence lake had a decided depression on the curve of the crest in which was found a blunt projection. If the various forms have different migratory periods and may inhabit different parts of the lake, to which may be added a reversal in movement due to seasonal variations, there is some reason for the irregularity in the readings. Whether the forms noted were seasonal variations of the same form or variations in the forms of different races is a problem for further study. Wolterecck and Wesenberg-Lund are doing considerable work on this matter and have yet to arrive at a conclusion satisfactory to both parties.
Bosmina - According to a chart by Worthington (Welch 1935) the adults and young of Bosmina show a decided variation in behaviour. The adults remain near the surface throughout the day, whereas the young descend to the depths during the bright sunlight - descent beginning with the sun lighting up the water. This would imply that in those section of the lake on which the sun can shine most of the day and which are inhabited by Bosmina - little variation in the numbers caught would occur during the day. An increase in numbers would take place when the sun left the lake in shadow and the young began to migrate to the surface. In general, this appears to be the case with the numbers of Bosmina obtained from Florence lake. During November the presence of a wind may have heaped up the extra amount of Bosmina on the west shore (Station 3).

Pleuroxus denticulatus Birge, Chydorus sphaericus, Alonella nana (Baird), and Holopedium gibberum Zaddach appear to be incidental plankters of Florence lake, though the first and last are reported from some lakes as being plentiful. Pleuroxus and Holopedium appeared more during the summer, while Chydorus and Alonella were of more common occurrence during the winter and early spring, though some of them were found in June. Insufficient numbers were obtained to draw any conclusions regarding their movements, though Pleuroxus would appear to be at the surface during the day and descend during the night.
Diaphanosoma brachyurum (Lieven).

(Welch 1935) Diagrams from Worthington would show a slight sinking of this organism during the day. This is scarcely so by the results obtained from Florence lake, but the numbers are not large enough to be of much significance. The two stations with deeper colder water show a reversal, namely, more in the morning and less toward night. It was never very abundant but seems to overlap into the beginning of the Ceriodaphnia bloom. Eddy (1934) describes it as a Serotinal predominant—that is, an organism present from July to September, which correlates with the results obtained as far a seasonal occurrence is concerned, but it is by no means a predominant in Florence lake.

Diaptomus washingtonensis Marsh.

This form was never very abundant. This might be expected as most species of Diaptomus inhabit deeper waters and the tows taken were from the surface. (Welch 1935 and Foerster 1925). Insufficient numbers were obtained to draw any conclusions regarding its migrations. Welch (1935) quotes that the adults show a slight diurnal movement to the depths, while the young show a decided migration of a similar nature. During February and March females with eggs were observed, during May and June many of the individuals were young, this was particularly so in the night hauls. The greatest numbers of adults were obtained during November and December.

Nauplii.

From a study of the graph from Stations 2, 3, and 5 it will
Seasonal Variation in Nauplii - showing variations in numbers at noon, source, and midnight, for one day.
be seen that the abundance of nauplii varies greatly with the season. A high peak in August and October is followed by a fall in numbers during November and December; this is succeeded by a high peak in February and March. A fall off occurs in March to be followed by the highest peak of the year during April and May. A minimum occurs in June followed by a rise during July. There are, then, three peaks throughout the year beginning at August, with each successive one greater than the one before.

That diurnal variations occurs is evident, but correlation was not obtained throughout the year. Several reasons for this might be suggested, such as variations in temperature in the different parts of the lake, light effects in the different parts of the lake, and what is most probable, the presence of different types of nauplii. Nauplii of one form may be more abundant in one part of the lake than another and have a different period of migration than the nauplii of another form. That is, nauplii of *Cyclops bicuspidatus* could have a different migration to *Cyclops phaleratus*; these in turn might vary from that of the nauplii of *Diaptomus washingtonensis*.

Correlation was obtained from March to July. During March a rise from noon till 5:00P.M. occurred followed by a descent to deeper waters. This is similar to the graph for August. In April a continued rise till midnight occurred. During May there was a peak at noon followed by a continued descent throughout the rest of the day.
Seasonal Variation in *Cyclops bicuspidatus*

Showing numbers at noon, 8:00PM and midnight for one day.
Cyclops bicuspidatus. Claus

Two peaks occur, a low one in August, September, and October, and a high one during the period of spring maximum in March. (Graph 4) Correlations in migration from Stations 2, 3, and 5 were obtained for the months of February, May, June and July. A movement to the depths from noon till 5:00 P.M. is indicated with a rise to the surface again at midnight. The other results do not correlate. The cause for this may lie in the reason suggested for the movement of the nauplii. Cyclops phaleratus was noted in the lake. It may have had a different movement to C. bicuspidatus. Its occurrence was more frequent in the fall than in the spring. Before any assertion can be made regarding its movements, a check-up will have to be made.

Hyalélla azteca  Saussure.

This was found in large numbers in the lake. It was found in the plankton at night from June to August. It appears to be heliophobe, preferring the dark shadows of the Nuphar areas in shallow water during the day, but found throughout the waters of the lake after dark. One specimen was found in the centre of the lake during the day, but in general, the above statements regarding its behaviour stands. Rawson (1934) to few being found below 10 metres. Ricker (1934) shows that during the winter these frequent the shallow edges of the lake inhabiting water between 1 and 2 feet.
Rotifera.

The lake possessed a rich fauna of rotifers. These showed seasonal periodicity and fluctuation in numbers. For example, *Asplanchna priodonta* Gosse, was more common in the summer, though never abundant at any time. *Notolca striata* and *Keratella quadrata* (Muller) were found during the early spring and winter. *K. quadrata* rose to its greatest abundance during February. Eddy (1934) classifies *K. quadrata* and *N. striata* as vernal predominants, occurring from February to June. In Florence lake they were found from December till March. At no time were they very abundant.

*Synchaeta* showed a predominence in the spring and fall. There may have been two species present as the forms were not specifically determined and there was some indication of there being two species in the lake. *Synchaeta* is one of the forms listed by Eddy as being a "Perennial Predominant". Lotka (1925) refers to the bloom of *Synchaeta* in early spring.

*Trichocera cylindricus* (Imhof) (Rattulus) rose to a peak between August and October with indications of its presence in July and November.

Such forms as *Monostyla*, *Diurella*, *Lepadella patella* (Meller), *Diurella*, and *Colurella* were incidentals. They were never present in sufficient numbers to determine a seasonal variation. It would appear that *Colurella* is an autumnal form, though verification of this would need to have further study.
Seasonal variation in Polsters
Numbers per cc from same volume.
Average number per day from Station 3.
The dominant forms were *Polyarthra trigla* Ehrenberg, *Keratella cochlearis* Gosse, *Gastropus stylifer* Imhof, and *Conochilis unicornis* Rousselet. *Gastropus stylifer* was confused with *Chromogaster ovalis* (Bergendal) which occurred in greater numbers during the months of December, February, and March. *Gastropus stylifer* reached a peak during October, becoming negligible during the winter, increasing slightly during June. There is some indication of a variation in numbers during the day and night. This may be due to temperature, wind currents or other factors already discussed, as well as depth of water. No correlation is shown from station to station.

*Keratella cochlearis* is said to show diurnal fluctuations. Whether one is justified for assuming this to be shown by the results is doubtful. Seasonal fluctuations in numbers is shown and some variation in form was noted; e.g., larger size of the animal and greater prominence of the spines during the winter. The peak of its numbers as shown in Graph 5 bear some resemblance to a graph in Eddy (1934) but any statement regarding the exact limits of these peaks cannot be made for the periods of its peak and the height of the same vary from year to year. This statement applies to all the other plankters dealt with. Some forms may rise to greater prominence one year than during another. How such cycles run calls for a great deal more observation. *K. cochlearis* in greatest numbers at Station 2 in the reedy section of the lake. Foerster (1925) reports a similar predominence in
shallow water. They were not found in the shallow north end of the lake in such large numbers.

*Conochilus unicornis* was found in greater numbers from Station 5 in the centre of the lake than at the shallower Stations. This agrees with Foerster's observations that it is found in the deeper regions of the lake in greater abundance than elsewhere.

**Protozoa.**

*Arcella* - was present in most of the hauls. More were obtained from the shallower Stations than from the deeper. This is as would be expected from its habits of growth. Predominence was during the fall and spring.

*Ceratium hirundinella* (O. F. M.). The form, if the same species was present throughout the year, took seasonal variation. Welch (1935) reports such a change occurring. The general shape during the winter months was more compressed than during the summer - the arms gradually spreading out from the winter form till that of the summer was attained. A small peak occurred during the fall but the organism disappeared during the winter. A gradual increase took place during February, this continued till a peak was reached in May after which there was a steady decline as the summer advanced. This organism, apparently, is more numerous in surface hauls (Foerster 1925) particularly in shallow water similar to that in which *Arcella* was found most abundantly.

*Dinobryon sociale* (?) Ehrenberg. During July 1934, this organism reached a very high peak. A sharp fall off in
Graph - 6

Seasonal variation in Ceratium and Peridinium.
Numbers per c.c. from 100 c.c. volume.
Average number per day from Station 3.
August followed. During October there was a slight increase in numbers, but from then till February there was practically none found in the plankton. A sudden increase occurred during February rising to the highest peak of the year in April. During May there was a mere indication of its presence, this was followed by an increase in June. There was a mere indication of its presence in the hauls for July. July 1935 was therefore, quite different from July 1934 as far as the counts for Dinobryon are concerned. This variation in the plankton from year to year is to be expected as food, weather conditions, ecological factors in general vary from year to year. (Eddy '34)

Vorticella. This organism was counted in its relationship to Anabaena and therefore its prevalence follows that of Anabaena; namely, a peak in June and August, the June peak being the higher.

Peridinium. was encountered in great numbers during October, November, and December, the highest peak occurring in November. A higher peak occurred in April, after which it disappeared during the summer. Yonge (1928) refers to the summer decline of Peridinium in the following," Exhaus-tion of the phosphates is as important as nitrogen as a cause of the summer decline of diatoms and Peridinium." (Ceratium also?)

Difflugia and Epistylis were incidentals.

Algae.

With regard to the general occurrence of the algae the following is a free-quotiation from G. M. Smith, 1935.
Graph - 7

Seasonal Variation in Diatoms

Numbers per cc from 100 cc volume
Average number for the day Station 3
Blue-green algae usually occur in abundance only during the warm months of the year, but certain species may develop in quantity during the winter, e.g., Gomphosphaeria. (This genus was found in Florence during February.) Soft-water lakes ordinarily have more Chroococcales than other Myxophyceae but these never predominate at any season of the year. Chlorophyceae is rarely a predominating organism in the phytoplankton of lakes and ponds, the number of species found in the fresh-water plankton is very large. As a general rule they are most abundant in late spring and early autumn.

**Anabaena.** Two peaks were noted; one in the fall, the other in early summer. It is called an Estival by Eddy (1934) as it occurs from March to December. In general this statement holds true for its occurrence in Florence lake.

**Diatoms.** Two peaks were noted; one in the fall, the other in spring. The spring peak being the higher. A bloom of Asterionella during December and lasting till February, is worthy of note. This diatom pollutes the water giving it a decided odour. (Whipple 1927). The various forms found and their occurrence has already been noted in the list of the organisms found in the plankton.

**Aphanocapsa Group.** As stated previously this group included several algae. Microcystis was found fairly abundantly in the fall and spring, making its appearance in April and rising to form approximately one-sixth of the total number of this group during the beginning of June. A fall in
the numbers of this form was noted during the summer. Aphanocapsa and Coelosphaerium also increased over the same periods as Microcystis.

Desmids.

These were never present in large numbers. In the mossy areas near shore many of the large forms such as Micrasterias, Euastrum, Cosmarium and Closterium were found. The odd individual of these forms was found in the plankton. Acidity (G.M. Smith 1933) appears to be needed for their development. A fall in numbers is noted after May. No definite statement can be made regarding its movements or localisation in any one part of the lake.

Gloeocapsa.

Like Aphanocapsa this group included several organisms. Of these Chroococcus was more abundant than the other forms during March. This form continued till the fall. This period of growth agrees fairly well with Birge and Juday's chart (Welch 1935). No definite statement can be made, as the period of growth is regulated by factors variable from year to year. Gloeocapsa appeared later than the former and became more abundant during the summer. During April a period of rapid cell-division appeared to have occurred throughout all the algae forms, but especially in the blue-greens.

Sphaerocystis.

The cycle appears to be as follows: and autumnal increase over the summer population; a disappearance during
the winter; a rapid increase during April; a decrease in June, followed by a rise in July. This is also fairly well represented in Birge and Juday's chart of seasonal changes of form found in the plankton of Lake Mendota. *Gloeocystis* would appear to have a similar cycle.

**Richteriella.**

Counts were not taken of this organism for the whole year. From those taken a decided peak is shown during the winter months. Whether the apparent correlation of greater abundance at noon of the plankton than at midnight throughout the majority of the hauls is significant cannot be definitely said, but light would be necessary for photosynthetic processes and the organisms might in some manner be attracted to it.

**Selenastrum.**

This group included several similar forms. Its periodicity is shown on the charts - there is a small peak in November, followed by a complete disappearance in winter. A sudden bloom occurs in April during the period of rapid proliferation of all the algae.
SUMMARY

1. A survey of the general ecological features of Florence lake was made.

2. Difficulty is ascertaining certain genera under the 16mm. objective necessitated the combining of some of the smaller algal forms into groups. This did not prove very satisfactory in giving the periodicity of members of the group but served to show fluctuations of the group as a whole.

3. Seasonal variations of all the organisms observed was found. The indicators of the seasons are listed below.

Perennial forms. The following were present throughout the year. Periods of abundance are noted for each species.

- Bosmina longirostris. Abundant from August to October.
- Keratella cochlearis. Abundant in the Autumn and Spring. Most abundant during the Autumn. (Graph 5).
- Polyarthra trigla. Most abundant during the Autumn. (Graph 5)
- Peridinium. Most abundant in the Autumn and Spring. (Graph 6)

Hiemal forms. (December to April).

- Asterionella formosa. Peak in December.
- Richteriella. Peak in December.
- Keratella quadrata. Peak in February.
- Selenastrum. Peak in April.

Vernal forms. (February to June)

- Notcholca striata. (Incidental in appearance from Feb-
ruary to March.)

Estival forms. (March to December)

**Daphnia longispina.** Peak from February to April.

(Graph 2)

**Asplanchna priodonta.** Incidental in occurrence.

**Anabaena.** Peak in June.

**Conochilus unicornis.** Peak in August.

Serotinal forms. (July to August)

**Diaphanosoma brachyurum.** Peak in July.

**Ceriodaphnia reticulata.** Peak from August to September.

**Rattulus cylindricus.** Peak in September.

**Geratium hirundinella.** had a very high peak during May and a lower peak during August. It was not observed during the winter from November till February.

**Dinobryon.** occurred in very large numbers during May and October. From November till February it was not seen to any extent in the plankton.

4. Indication of diurnal movements in some of the groups is shown; e.g., Nauplii, Cyclops, Daphnia and some of the rotifers. Correlation, from all sections of the lake, of such movements was not obtained. This may have been due to one of several ecological factors other than light acting on the organisms; e.g., wind currents, or it may have been due to error in making the hauls.

5. Charts were made showing the numbers of organisms
found at each station throughout the year. Graphs were con-
structed showing the fluctuations in the representative
organisms throughout the year.

6. The of large quantities of certain organisms in the
lake explained the presence of a distinct odour and tainted
taste present in the water. A list of the organisms and
the odour given by each, follows:

Synura - cucumber odour. Spring and Autumn occurrence,
though never abundant;

Asterionella - Present in large number during the winter
months. This diaton produces a very decided od-
our. In small numbers it produces and odour re-
sembling rose geranium; in large numbers it
gives a decidedly fishy odour.

Mallomonas - This was never very plentiful. It produces
a sweet smell like violets. In large numbers it
produces a fishy odour.

Anabaena - was fairly plentiful during the month of June.
This gives off a nasturtium odour, when present
in small numbers. When present in large numbers
it gives off the odour of a pøgpen.

Tabellaria - when present in large numbers, as it was at
the same time as the bloom of Asterionella gives
off a decidedly fishy odour.

Eudorina - though never very plentiful in the lake at any
time, this organism gives off a fishy odour.

Ceratium - has a vile stench and gives a rusty brown col-
oration to the water.

*Dinobryon* - was present in large numbers at various times of the year. This gives a fishy odour to the water.

*Peridinium* - gives off a strong fishy odour like clam-shells.

Considering the organisms present and the overlapping of their periods of abundance there is little chance for the water of the lake to free itself of these objectionable odours. The fact that the lake is a closed system, also prevents any chance of eliminating the odours present.
CONCLUSION

The need for the study of interrelationships in any ecological study is aptly described by Shelford (1931).

1. Weaver and Clements ('29) hold that food, rather than physical factors, controls animals, and, since plants are the direct and indirect food of all animals, the biotic community has unity through food relation.

2. The food relation, especially of abundant and influent animals, are usually flexible and rarely if ever obligate, and observation of apparently restricted food relations made in one locality may not hold good under other conditions.

3. The climaxes of nature (bioecological climax) include that vegetation which occurs with the pristine numbers and kinds of animals present.

4. Plants and animals tend to move together as a unit, and are governed by physical factors. Animals may, because of their motility find suitable place in advance of the appearance of the plants.

5. Animals are better short-period indicators than plants. Their presence and abundance at any hour, day, season or cycle is indicative of conditions relative to which plants cannot fluctuate at all or must lag behind indefinitely. One thus sees the pushing of the dry community animals into the wet community in dry seasons and vice versa, as a regular phenomenon (Gleason, '27) with attendant effect upon the habitat.

6. Law of Tolerance. The growth of an organism is pro-
portional to the nutrient substance present in minimal quantity, no matter how abundant others may be. Thus food, Temperature, light, moisture, etc; may be favourable while shelter is lacking, and animals, which otherwise would be present and abundant, are absent or found in minimal numbers only.

7. Food relation. Each species selects the food available in greatest quantity, making selection which in a particular locality tend to give an erroneous impression as to the specific nature of food relations.

Of methods to be employed in the investigation of Animal ecology, he states: (1930)

1. Such studies should be carried through as many seasons as possible, but at least through two growing seasons, at the end of which biological differences may be correlated with weather.

2. -- in fact, all groups show fluctuations in abundance which are probably due to weather.

3. Papers on food relations should be accompanied by enough quantitative collecting of available food species to indicate the selection made by the specimen eating the food. This brings out interactions of species.

These points tend to emphasize the intricacies of any ecological work and the necessity of approaching it from as many angles as there are ecological factors before any conclusion is made regarding their interrelationship.
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Note: Counts recorded as no. of intake volume from air.
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| Counts recorded as numbers per cu. ft. of 10 cu. volume obtained in length of hauls noted.